'Forever chemicals'? Maybe not

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Heavily modified shipping containers at EDL's research and development facility in Henderson, Auckland, house the company's patented Mechanochemical Destruction (MCD) reactors. Credit: EDL Ltd

Dangerous "forever chemicals" left in the soil from firefighting foam

could be destroyed by grinding, according to a proof-of-concept study by University of Auckland scientists collaborating with the U.S. Environmental Protection Agency.

"Ball milling" appears viable for decontaminating soil from military bases, airports, and refineries around the world where the foam was used over decades, according to the University and Environmental Decontamination (NZ) Limited (EDL).

Contaminant chemicals called PFAS (per- and polyfluoroalkyl substances) don't break down naturally and, at certain levels, have been linked to cancers, reduced fertility, liver damage and other adverse health effects.

"Cleaning up PFAS from the environment is a massive task that will require our continuous and dedicated investment in the coming years," US President Joe Biden's White House said in March. Individual sites can have thousands of tons of contaminated soil, with the US Department of Defense estimating in 2021 that its clean-up could cost $31 billion.

Ball milling in a University of Auckland chemistry laboratory destroyed 99.88 percent to 100 percent of PFAS in soil from a decommissioned New Zealand Defence Force firefighting training site and in firefighting foam.

Intense grinding at an extremely high speed by metal balls left a safe by-product, according to Dr. Kapish Gobindlal, an honorary academic at the University and the chief scientist for the company EDL.

Published in the academic journal *Environmental Science: Advances*, the research was by Gobindlal and his Ph.D. supervisors, Professor Jon Sperry and Dr. Cameron Weber, of the University's Centre for Green

Chemical Science. Collaborating were scientists Erin Shields and Andrew Whitehill of the US EPA.

"We've established proof-of-concept and believe this method can be scaled up faster and cheaper than alternatives," says Gobindlal. "There is a massive need—the US alone has thousands of contaminated sites and regulation is shifting toward mandating remediation of these sites."

It's exactly what Sperry hoped to achieve when the University set up the Centre for Green Chemical Science, which puts the environment at the forefront.

"Work in the lab is flowing quickly toward real-world benefits," Sperry said. "This is an example of green chemistry that can help communities, the environment and, in fact, the world."

Numbering in their thousands, forever chemicals resist water, oil and heat, famously featuring in Teflon non-stick pans but also in everything from burger wrappers and pizza boxes to waterproof clothing.

Firefighters used "aqueous film-forming foam" containing PFAS to blanket and smother flammable liquid fires.

PFAS are in animals—even plankton—and in humans' blood and breast milk because of carbon-fluorine bonds which prevent the chemicals breaking down. Like microplastics, they are ubiquitous, turning up in drinking water and even rain.

While contaminated soil is only part of the problem, it's a big part.

In some ways, "ball milling" is not all that different from the grinding of a mortar and pestle, but at an extremely high intensity, with the balls moving at incredible speeds to degrade the PFAS at a molecular level,

says Gobindlal.

Crucial to ramping up is cost, including whether the grinding process requires expensive additives. Affordable and easy-to-source quartz sand was used as part of the treatment for firefighting foam, says Gobindlal, while no additive was needed for soil.

Laboratory benchtop experiments at the University from 2018 to 2023 typically involved 10 to 30 small metal balls colliding to destroy PFAS in soil, in firefighting foam, and in media such as activated carbon, which is used to remove PFAS from water. The process left an inert powder suitable for being a grinding additive or non-hazardous fill.

Heavily modified shipping containers at EDL's research and development facility in Henderson, Auckland, house the company's patented Mechanochemical Destruction (MCD) reactors, intended to treat contaminated soil at speed and scale—potentially dealing with several tons per hour.

In New Zealand, PFAS soil contamination occurred at locations such as Royal New Zealand Air Force bases Woodbourne (west of Blenheim) and Ohakea (near Palmerston North). Banned in New Zealand in 2011, the firefighting foams were still found at sites including airports years later, according to New Zealand's Environmental Protection Agency.

Last year, Channel Infrastructure NZ, an operator of the Marsden Point Oil Refinery in Northland, was fined for using firefighting foam containing PFAS.

"In addition to the known PFAS-contaminated locations, there are likely many more unknown sites yet to be identified through active investigation from both governmental and private entities," according to Gobindlal. "We're likely just at the tip of the iceberg."

In the US, the chemical and manufacturing company 3M negotiated a $10 billion settlement with cities and towns over PFAS pollution in water. In Europe, a group of news organisations including Le Monde say at least 17,000 sites across Europe and the UK are contaminated with PFAS.

New Zealand's EPA has proposed a ban on PFAS in cosmetics. The chemicals are in our drinking water, but at lower concentrations than in other countries.

Levels in water "are still concerning because PFAS bioaccumulate and biomagnify; they build up in our bodies, environment, and food web," wrote Dr. Lokesh Padhye, Dr. Erin Leitao, and Dr. Melanie Kah, of the University's faculties of science and engineering, in *Newsroom* in March

More information: Kapish Gobindlal et al, Mechanochemical destruction of per- and polyfluoroalkyl substances in aqueous film-forming foams and contaminated soil, *Environmental Science: Advances* (2023). DOI: 10.1039/D3VA00099K

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